



Analysis of Trident Events

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DONUT Collaboration Meeting

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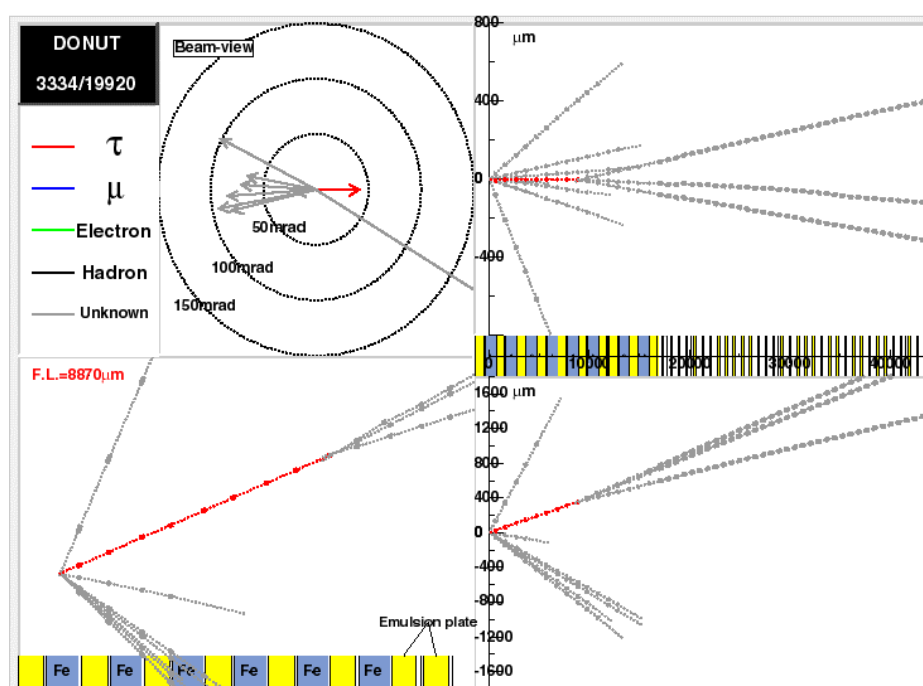
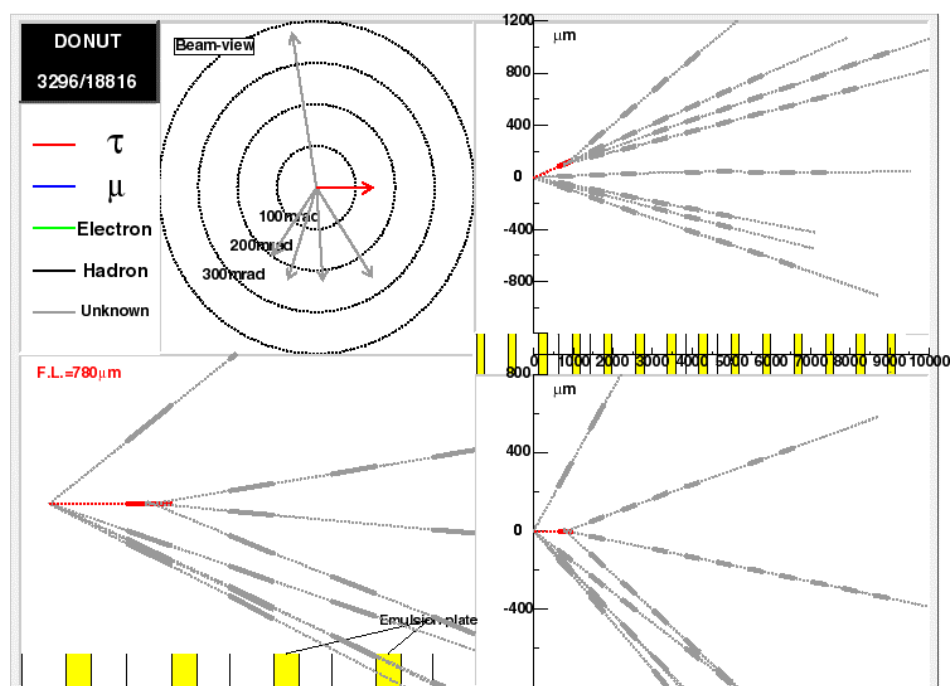
Outline

- Parameters
- Bayesian Probability
 - Prior Probability
 - Probability Density
- Results for Tridents
- A Note on Single Prong Events
- Conclusions
- Future Extensions





New n_t Trident Candidates

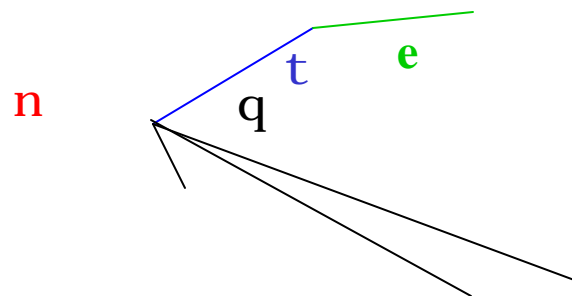




Production Angle q

- Angle between the original neutrino direction and the candidate t track

Event	q
3334_19920	39.8 mrad
3296_18816	141 mrad

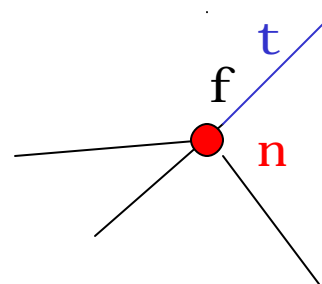




Phi Asymmetry Δf

- f Asymmetry
 - Measure f for all tracks
 - Average the f angles for all non-tau tracks
 - Subtract f angle of t track from average f

Event	Δf
3334_19920	3.11 rad
3296_18816	1.74 rad

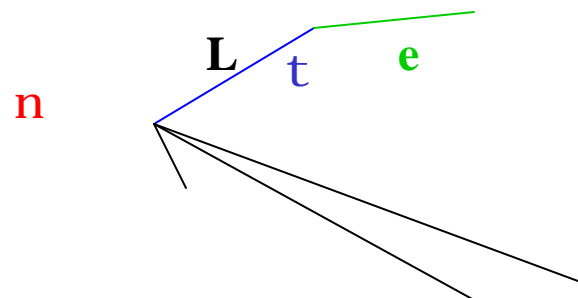




Decay Length L

- Decay length of the candidate t track

Event	L
3334_19920	8.87 mm
3296_18816	0.78 mm





Bayesian Probability

$$P(i) = \frac{PP_i \Pi(i | j)}{PP_i \Pi(i | j) + \sum_{bkg} PP_{bkg} \Pi(bkg | j)}$$

$P(i)$ is the probability event is an i type event,
where i is a tau, charm, or interaction

PP_i is the prior probability

apriori knowledge of the likelihood of event type

$\Pi(i | j)$ is the probability density function

measure of simulated events which reside in a region of
parameter space centered around the parameters of the event





Prior Probability of n_t

$$PP_{n_t \rightarrow 3} = \frac{N_{n_t} P(\tau \rightarrow 3 \text{ prong})}{N_{events}}$$

N_{n_t} is the number of n_t events expected in the data

$P(\tau \rightarrow 3 \text{ prong})$ is the probability that a tau will decay to 3 charged particles

N_{events} is the total number of events (429)





Prior Probability of Charm

$$PP_{charm \rightarrow 3} = \sum_i \frac{N_{charm_i} P(charm_i \rightarrow 3prong) \mathbf{X}}{N_{events}}$$

N_{charm_i} is the number of charm particles expected of type i which is either D , D_s , or Λ_c

$P(charm_i \rightarrow 3prong)$ is the probability that the charm particle will decay to 3 charged particles

\mathbf{X} is the probability that the primary lepton is not identified





Prior Probability of Interaction

$$PP_{scatter} = \frac{\sum_i L_i P(\text{int})_i}{N_{events}}$$

L_i is the total length of all the hadron tracks through material i -iron, emulsion, or plastic

$P(\text{int})_i$ is the probability that the hadrons will interact to produce 3 charged particles in material i





Results of Prior Probability

Type of Event	Prior Probability
Tau Neutrino	5.92×10^{-3}
Charm Decay	2.05×10^{-3}
Hadronic Interaction	5.48×10^{-3}





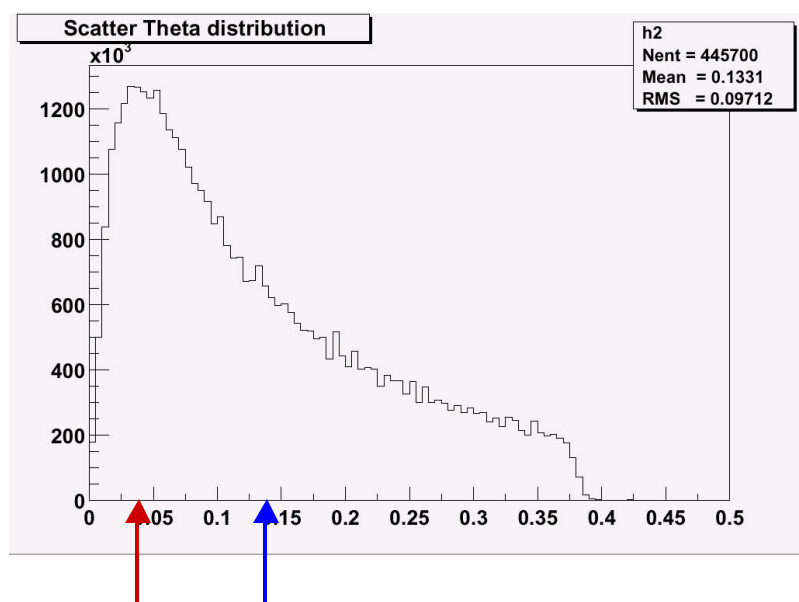
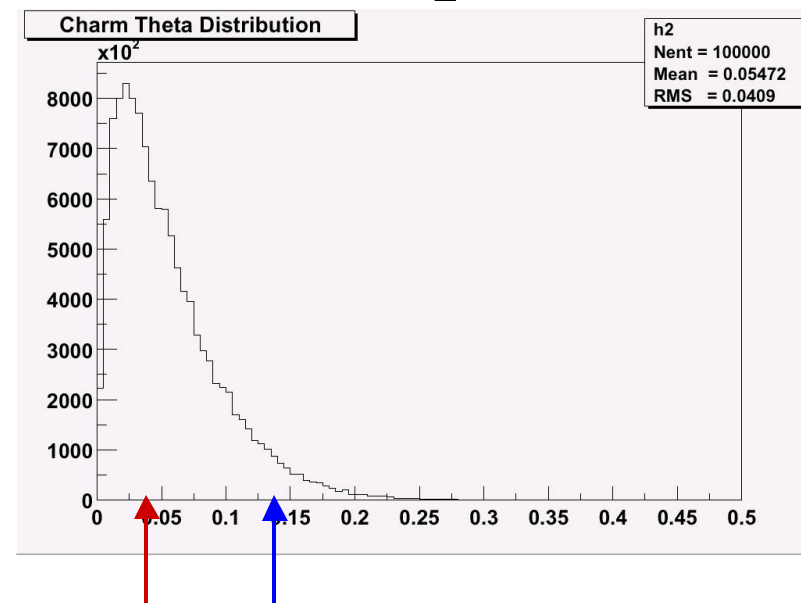
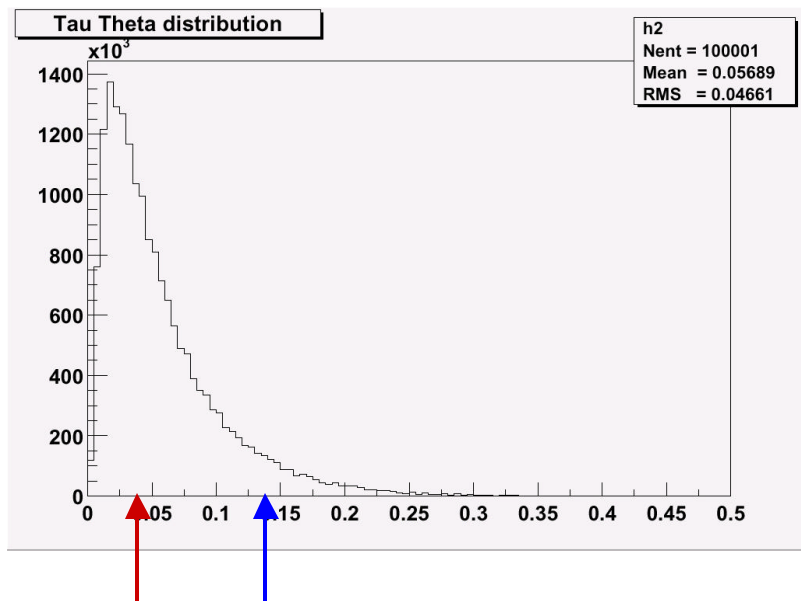
Probability Density

- Calculated using simulated data for each type of event using Jason's simulated data
- Measured by calculating fraction of simulated events which reside in a region of parameter space
- Region of parameter space is centered on the Δf , \mathbf{q} , and L of each event





Distributions for q



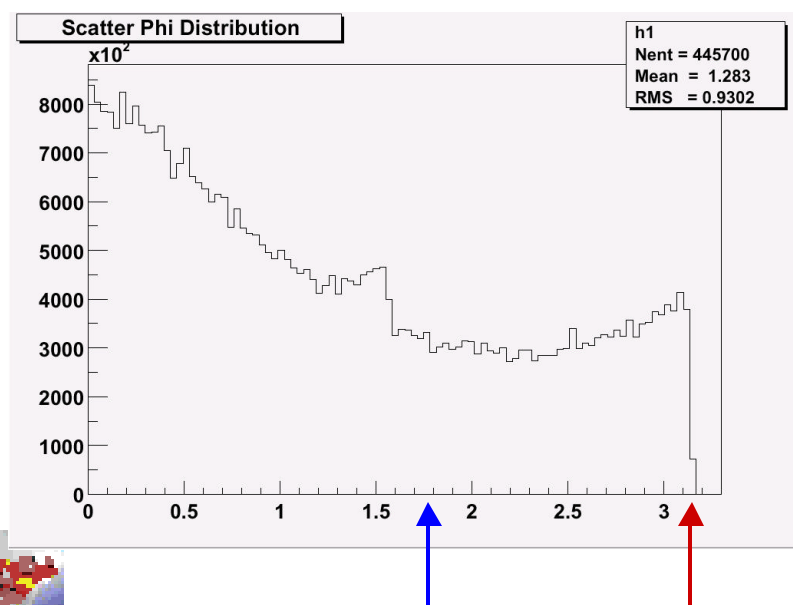
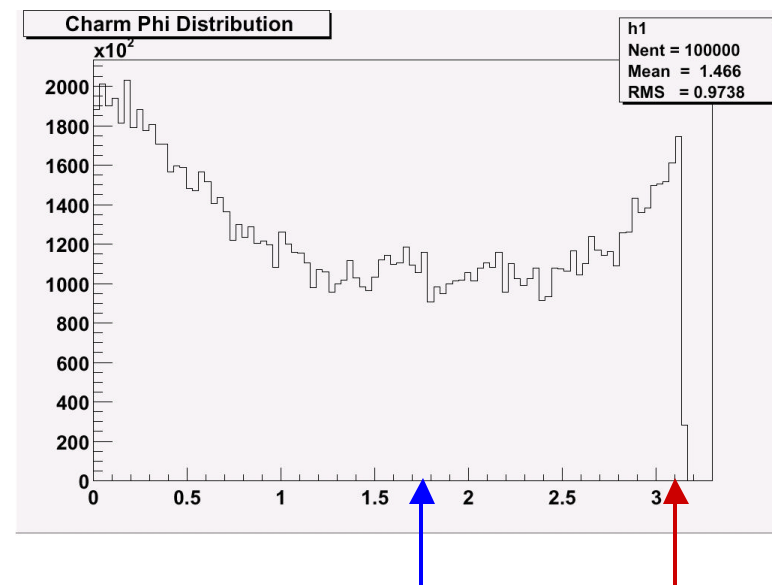
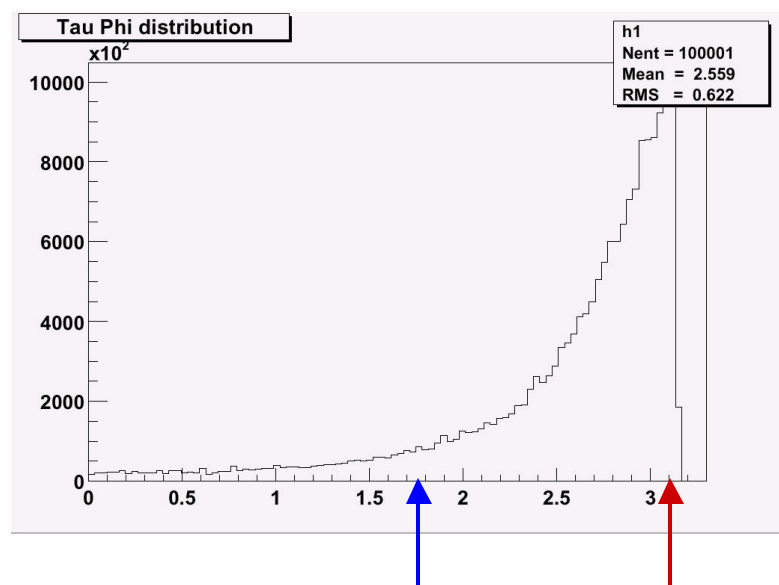
3334_19920

3296_18816





Distributions for Δf

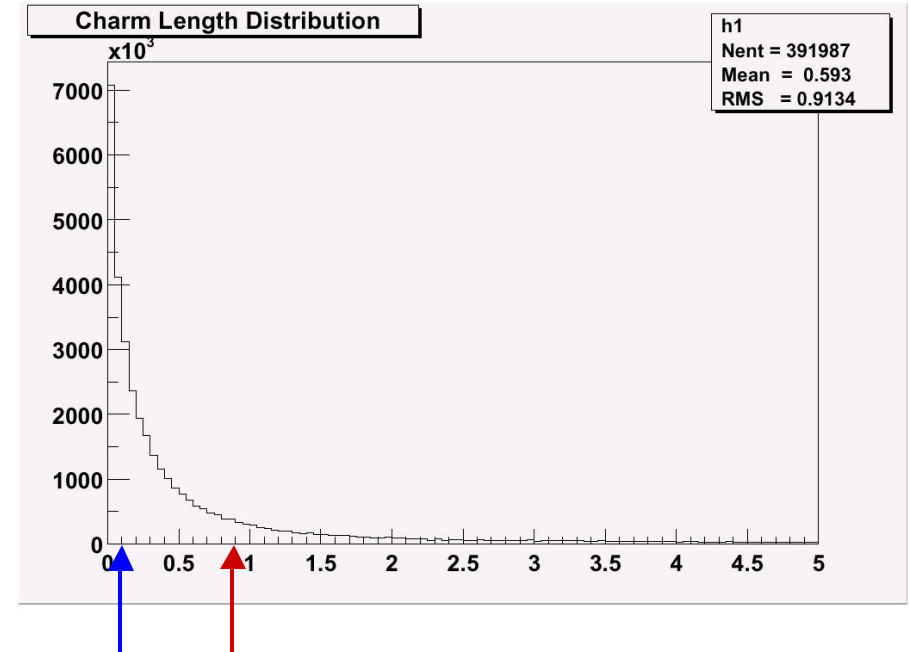
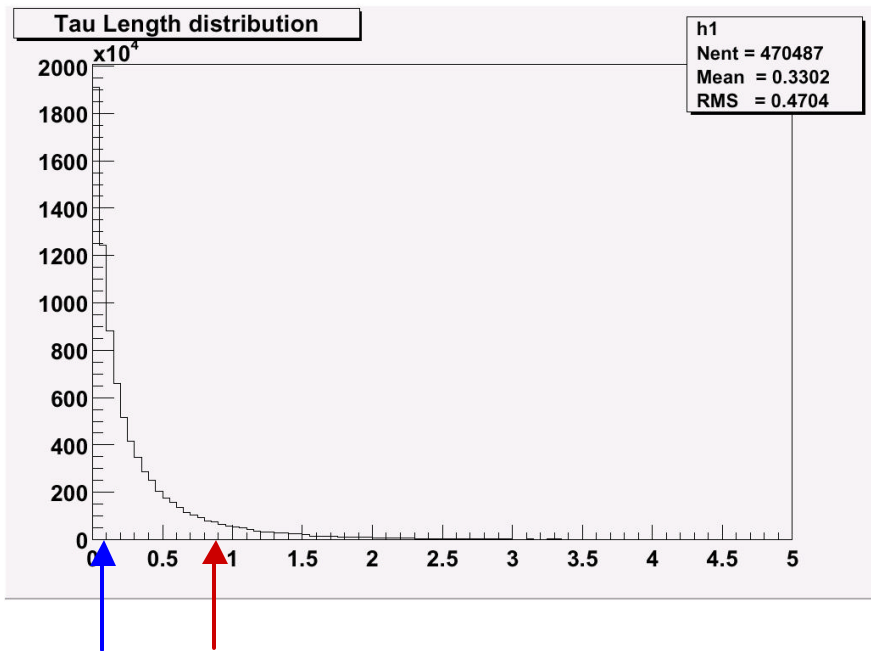


3334_19920

3296_18816



Distributions for L



3334_19920

3296_18816





Results for Probability Density (in $1/\text{rad}^2\text{mm}$)

Type of Event	3334_19920	3296_18816
Tau Neutrino	1.653 _(1/rad²mm)	0.545
Charm Event	0.565	0.020
Interaction Event	0.042	0.052





Results for Tridents

Type of Event	3334_19920	3296_18816
Tau neutrino	0.88	0.91
Charm Event	0.10	0.01
Interaction	0.02	0.08





Single Prong Events

Event	New <i>t</i>	Old <i>t</i>	New Charm	Old Charm	New Scatter	Old Scatter
3024_19920	0.870	0.698	0.130	0.302	0.00	0.00
3039_01910	0.996	0.982	0.002	0.018	0.002	2.6×10^{-4}
3263_25102	0.060	0.130	0.030	0.140	0.910	0.730
3333_17665	0.994	0.985	0.002	0.015	0.004	0.00

Note the new analysis only uses 3 parameters while Jason's analysis (the old analysis) uses 5 parameters.





Conclusions

- 3334_19920 and 3296_18816 are both most likely to be tau neutrino trident events according to this analysis
- This analysis produced similar results to Jason's analysis





Future Extensions

- Calculating efficiencies for locating trident events
- Use current data set to calculate more accurate values for number of expected \mathbf{n}_t interactions, number of expected charm background decays, and total lengths of hadron tracks in different materials
- Add parameters to this analysis which relate to decay products

